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A SEED ORCHARDIST'S GUIDE TO THE HANDLING OF INSECTICIDES AND THE CALIBRATION OF SPRAY EQUIPMENT

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ABSTRACT

This guide booklet briefly summarizes the basic principles of insecticide application in forest tree seed orchards. It emphasizes the safe handling of insecticides, presents formulas and instructions for mixing insecticides correctly, and gives the characteristics of different types of spray machines and the methods of calibrating them.

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INTRODUCTION

A seed orchardist is truly a Jack-of-all-trades. In the management of his orchard he must draw upon the knowledge and techniques of many disciplines, such as forestry, genetics, economics, pathology, and entomology. Although it is unreasonable to expect him to become an expert in these subjects, he should have a good working knowledge of the practical aspects of each as they apply to seed orchard management. Insect control is a major facet of such a program. Recognition of its importance is emphasized by the establishment in 1966 of a Seed Orchard Insect Research Project by the U.S.D.A. Forest Service at the Southeastern Forest Experiment Station. Five entomologists are now studying orchard insects and ways to control them.

Many southern pine seed orchards are beginning to come into full production, and, as they do, seed orchard managers are quick to recognize the need to protect this valuable crop from insects. They turn to the most obvious, and at present, one of the most effective methods of insect control — insecticides. It has been estimated that, in the Southern Region alone, $½ million is being spent annually for this purpose.

We have talked and corresponded with many seed orchardists throughout the South. There seems to be a lack of understanding among the majority of them about the handling of insecticides and the equipment used to apply them. The objective of this paper is to fill that void and to guide the orchardist to some of the more detailed sources of information.

There are three basic rules for the chemical control of insects. By strict adherence to these rules, an orchardist can achieve maximum effectiveness and safety in his control program.

1. Properly identify the insect. Determine whether an insect problem actually exists in the orchard.

2. Apply a recommended insecticide at the right time and in the right way.

3. Take all the necessary precautions to protect personnel when they are handling, mixing, applying, and storing insecticides.

Mention of trade names throughout this paper does not constitute endorsement by the U. S. Department of Agriculture to the exclusion of other, equally acceptable products.

SAFETY IN HANDLING INSECTICIDES

Safe use of insecticides is easy to talk about, but, for some reason, often hard to practice. Insecticides are poisons that can be fatal if swallowed, inhaled, or absorbed through the skin (see figures 1 and 2). But even the most toxic of these materials can be safely handled if precautions are taken.

General Precautions

There are a number of general precautions that should be followed when handling any insecticide. They should become good habits and not just good rules.

1. Read the manufacturer's label *Carefully* and *Completely,* paying particular attention to precautions and antidotes.

2. Use only recommended materials, dosage rates, and methods of application.

3. Always mix pesticides in an open area where ventilation is adequate; never mix pesticides in an enclosed area.

4. Avoid ingesting or inhaling pesticides. Never use your mouth to siphon insecticides from one container to another.

5. Insofar as possible, avoid contact of the insecticides with your skin. If concentrates of insecticides are spilled on skin or clothing, remove the clothing at once and wash your skin thoroughly with soap and water.

6. Dispose of empty containers promptly and safely. Crush nonpressurized cans, puncture plastic containers, and break glass containers so they cannot be reused for other purposes.

7. Wear adequate, clean, protective clothing.

8. Never use your mouth to blow out nozzles or clogged lines on equipment.

9. Never use your hands and arms to stir insecticides or reach into sprayer tanks containing insecticides to retrieve tools or other items.

10. Never use sprayers with leaking hoses or connections.

11. Make a habit of washing your hands frequently, especially before eating, drinking, or smoking.

12. Remove clothes after using poisonous chemicals and bathe with plenty of soap and water. Wash work clothes with a good detergent before wearing them again.

13. If symptoms of poisoning occur during or shortly after spraying or dusting, immediately call a doctor or go to a hospital. Post a typed or clearly printed list of up-to-date emergency instructions in both the work and office areas. Be specific! List doctor's name, phone number, as well as the phone number of the nearest hospital.

14. When application equipment is not being used, keep it in an area where children and livestock cannot get to it.

15. Store pesticides in the original labeled containers away from food, feed, or medicine and out of reach of children, pets, and livestock.

Special Precautions for Highly Toxic Insecticides

Additional special precautions are warranted when applying highly toxic insecticides such as Bidrin®, disulfoton (Di-syston®), and phorate (Thimet®).

1. When *mixing* and *applying* these materials, use a chemical cartridge respirator approved for the specific pesticide and wear protective clothing, long sleeves, a washable rain hat, rubber boots, and gloves (figures 3 and 4). When handling granular insecticides, cover exposed arms and face to prevent dust from sticking to your skin.

2. Start with clean clothing each day and change if garments become wet with spray. If a liquid formulation is spilled on garments, remove them at once and take a bath. Take a thorough bath as soon as the workday is finished.

3. Mix materials and load application equipment only in the open.

4. Look ahead! Have soap, water, and clean clothes on hand in the field in case of an accidental spillage of the insecticide.

5. Never spray directly into the wind or directly overhead. Granular insecticide formulations are extremely dusty and should be applied when the air is calm or when a light breeze will carry the dust away from the applicator.

6. Wash spray equipment daily to avoid hazardous accumulations.

7. Clean respirators between operations by washing and replacing filters or filter cartridges at intervals recommended by the manufacturer. Always remember, protective equipment is relatively cheap and replaceable — *lives are not!*

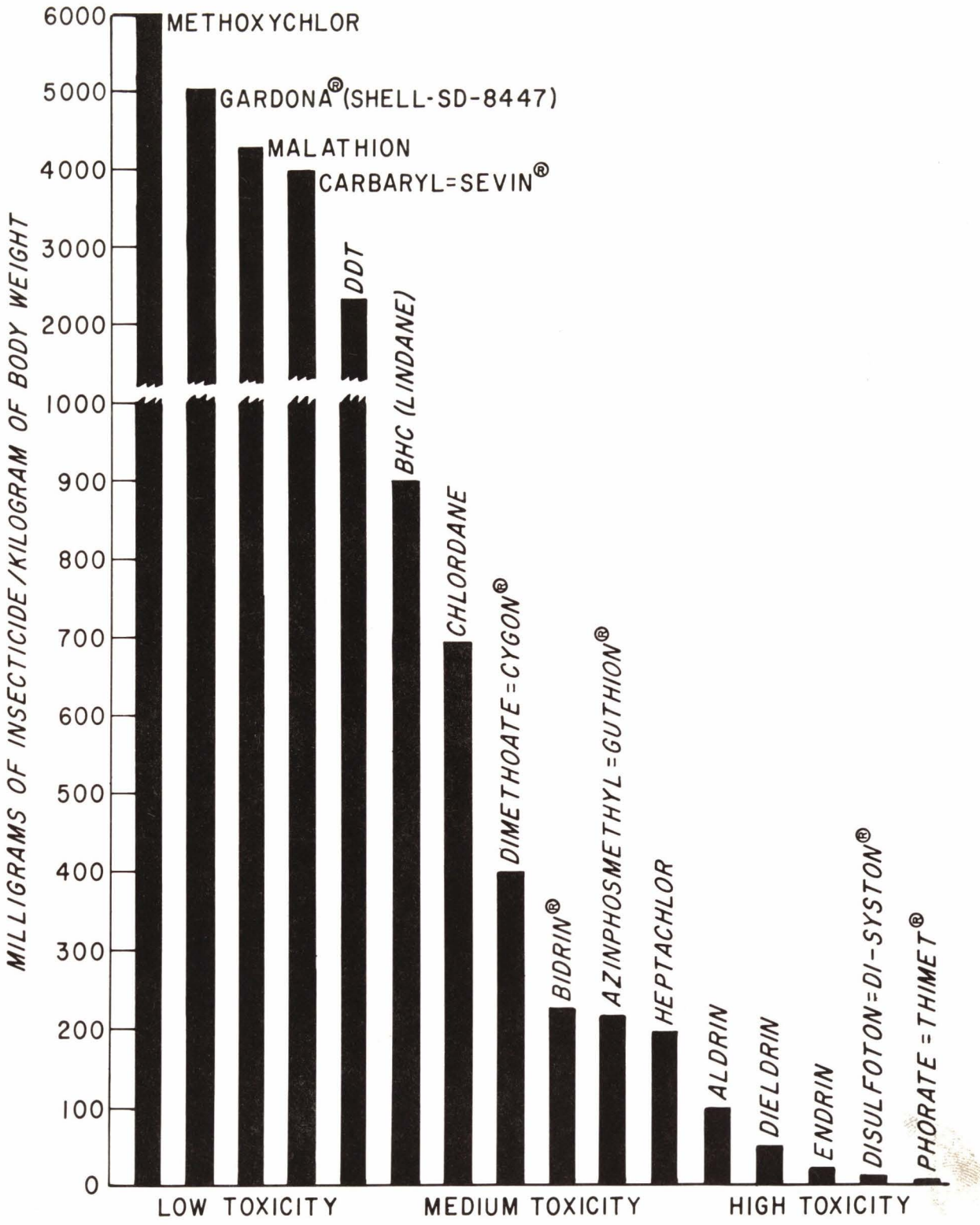

Figure 1.—Relative acute dermal toxicities of insecticides commonly used by foresters and seed orchardists (based upon dermal tests with rats). The higher the bar, the safer the insecticide.

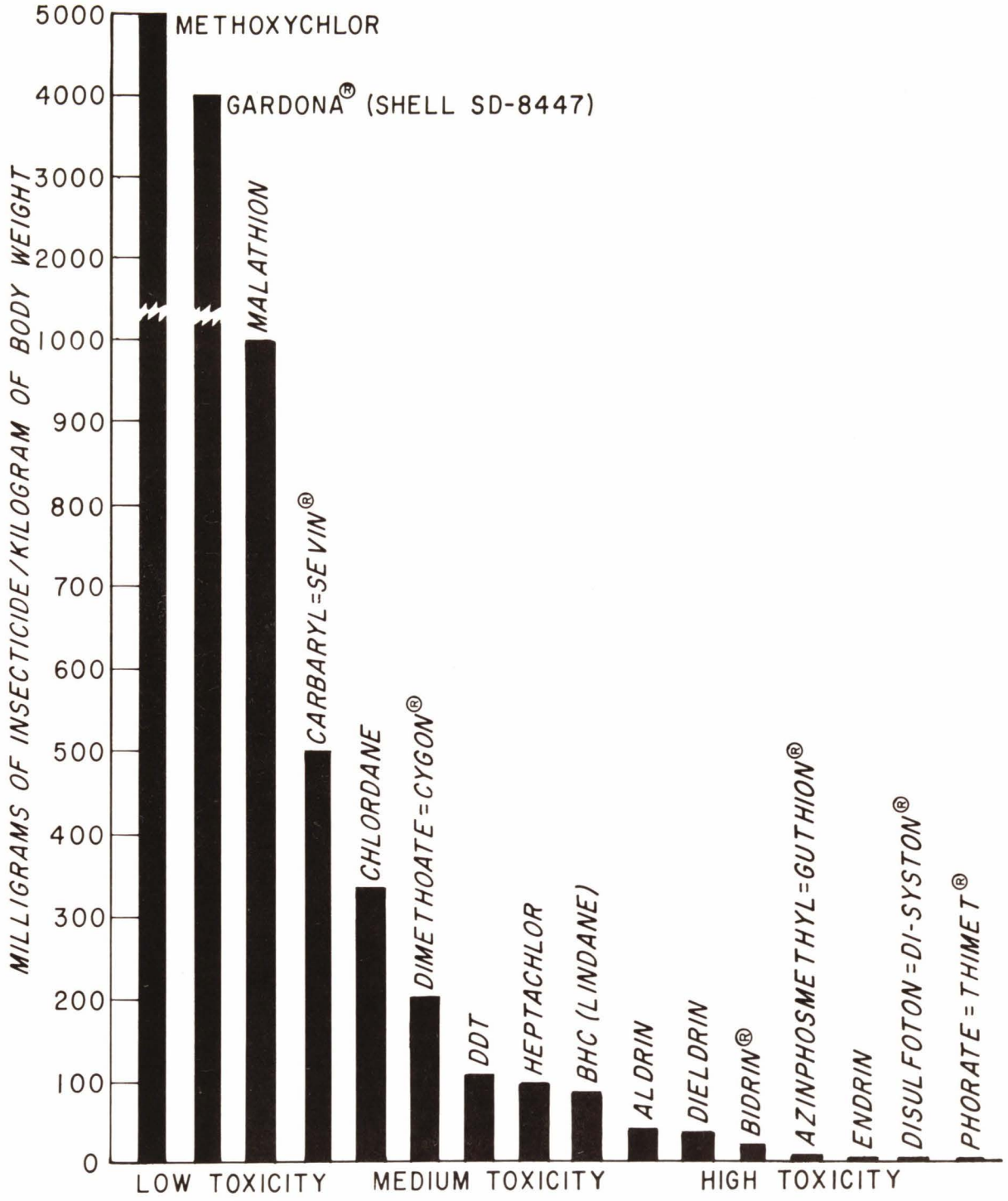

Figure 2.—Relative acute oral toxicities of insecticides commonly used by foresters and seed orchardists (based upon oral tests with rats). The higher the bar, the safer the insecticide.

Figure 3.—Proper protection of operator — respirator, face shield, hard hat, rubber suit, and gloves.

Figure 4.—An example of a safe method of applying dusty, granular insecticides in seed orchards.

CHARACTERISTICS OF THE SPRAY EQUIPMENT COMMONLY USED IN SEED ORCHARDS

The seed orchardist can use his particular spray equipment most efficiently when he has a good working understanding of its fundamental characteristics. Therefore, a brief review of some of these fundamentals seems appropriate.

Hydraulic Sprayers

Hydraulic sprayers are designed to deliver large volumes of dilute spray under high pressures. Most of them are equipped with one or more hand-held, trigger-type spray guns (fig. 5). There are three disadvantages of hydraulic rigs that limit their use in seed orchards:

First, because water is the dispersal medium for hydraulic machines, a large volume of water is required to obtain complete coverage of the spray material within the tree crown. For example, in order to obtain adequate tree coverage for control of coneworms, *Dioryctria* spp., and seedworms, *Laspeyresia* spp., several gallons of water must be applied to each individual tree — the actual volume depending on the size of the tree.

Figure 5.—Hydraulic sprayer equipped with a hand-held, trigger-type spray gun.

Second, it is time-consuming to spray an orchard of cone-producing trees with a hydraulic rig. To get complete coverage of the crown, the operator must stop at each individual tree and thoroughly wet the foliage to the point of runoff.

Finally, the vertical height to which the spray can be propelled is often quite limited with hydraulic rigs. Thus, as the orchard trees grow taller and become more productive, the hydraulic rig becomes less and less efficient.

Airblast Sprayers

Airblast sprayers and mist blowers are designed specifically for shade trees and for use in groves and orchards. As with the hydraulic rigs, the spray material is transported under pressure by means of a hydraulic pump. In addition, airblast machines are equipped with a fan or blower that provides large volumes of air at velocities in excess of 100 m.p.h. (fig. 6). This air is used to break up the water into droplets and to distribute the spray material throughout the tree crowns. Some airblast machines are designed for single-side discharge (fig. 7), while others may be used for either single or double-side discharge (fig. 8). Airblast sprayers are designed to overcome the three basic disadvantages of hydraulic sprayers:

First, because their dispersal medium is a combination of air and water (or almost entirely air in the case of mist blowers), airblast machines do not require the large volumes of water that hydraulic sprayers do.

Second, because they cover trees adequately when pulled slowly behind a tractor, airblast machines can spray an orchard more rapidly than hydraulic sprayers can.

Finally, because their blowers emit air at high velocities, airblast machines can spray to a greater height than hydraulic sprayers can and, consequently, are more efficient on tall trees.

In addition, airblast machines have two other advantages worth noting. First, because of their speed and efficiency, they reduce labor costs. Second, certain types of airblast machines, such as mist blowers, can be used to apply concentrate sprays. As will be explained later, concentrate sprays can be applied with less spray material and, hence, at reduced insecticide costs. But to obtain maximum efficiency and, in turn, effective insect control with airblast machines, the orchardist must operate and calibrate them correctly.

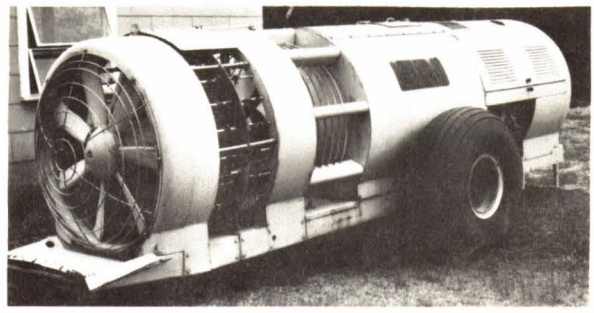

Figure 6.—An airblast machine equipped with a multiblade fan which provides large volumes of air at high velocities.

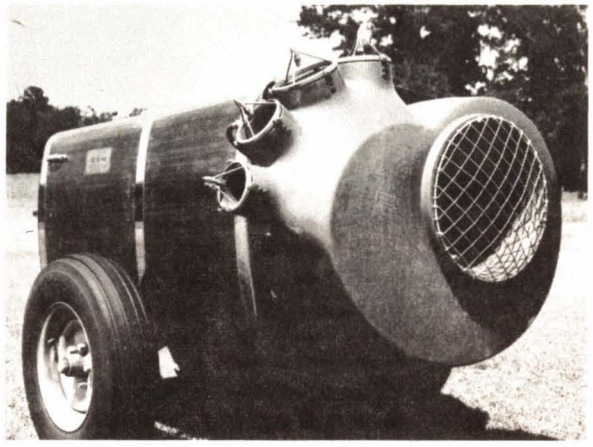

Figure 7.—An airblast sprayer designed for single-side discharge.

Figure 8.—An airblast sprayer designed for double-side discharge. (Photo by Georgia Forestry Commission.)

OPERATION AND CALIBRATION OF SPRAY EQUIPMENT

Before any piece of spray equipment can be operated properly in a seed orchard, its discharge rate must be adjusted to meet the specific set of orchard conditions and must then be verified. The testing or verification of the discharge rate (the volume of spray material discharged per minute) is termed calibration. Calibration of spray equipment is an essential part of any successful spray program, although it is often neglected by many seed orchardists.

Hydraulic Sprayers

The calibration of a hydraulic spray rig is relatively simple. Two variables are used to adapt the sprayer to the specific conditions of a particular orchard: size of the nozzle orifice and pressure (table 1). The following basic relationships exist:

1. Increasing the pressure causes an increase in the discharge rate and in the maximum height to which the spray can be propelled.

2. Increasing the size of the nozzle orifice causes an increase in discharge rate and a decrease in pressure and in the maximum height to which the spray can be propelled.

The best combination of nozzles and pressure depends upon the size of the trees in the orchard and the model of machine being used. After the orchardist has decided upon the best combination of nozzle orifice and pressure for use in his particular orchard, he can determine the gallonage or amount of dilute spray required for adequate coverage of the trees. The procedure is as follows:

1. Fit the sprayer with the desired nozzles and regulate the pressure to produce the best combination of factors for the size of trees in the orchard.

2. Fill the tank with a measured volume of water.

3. Spray as many trees to the point of runoff as the volume of water will fully cover. Tractor speed is not an important factor in hydraulic spraying because adequate time must be allowed at each tree to obtain thorough wetting of the foliage.

4. Calculate the number of gallons of dilute spray required to fully cover an individual tree to runoff:

$$\text{Number of gallons per tree} = \frac{\text{Number of gallons of spray used}}{\text{Number of trees sprayed}}$$

5. Then, the number of gallons of dilute spray required to spray the entire orchard can be calculated on a gallons-per-acre basis:

$$\text{Number of gallons needed per acre} = \frac{\text{Number of gallons}}{\text{tree}} \times \frac{\text{Number of trees}}{\text{acre}}$$

Table 1.—Effect of pressure and size of nozzle orifice on the discharge rate and maximum height of spray for hydraulic sprayers[1]

Pressure	Size of nozzle orifice	Discharge rate	Height of spray above gun
p.s.i.	*64ths of an inch*	*g.p.m.*	*Feet*
400	6	3.3	30
600	6	4.0	33
800	6	4.6	35
400	10	9.8	45
600	10	11.9	50
800	10	13.8	55
400	14	21.2	40
600	14	25.0	48
800	14	26.8	60

[1] Taken from Bailey, S. F., and Smith, L. M., Handbook of agricultural pest control. New York: Industry Publications, Inc. 1951.

Airblast Sprayers

While the operation and calibration of hydraulic sprayers is fairly simple, the job becomes more complex and more important with airblast machines. The reason is obvious —there are more variables to contend with when working with airblast sprayers. In addition to pressure and size of nozzle orifice, these include tractor speed, airblast velocity and direction, number of nozzles, and single-side or double-side discharge. The operator's failure to consider one or more of these factors will greatly reduce the efficiency of the machine and, in turn, the effectiveness of the entire spray program in an orchard.

Most airblast machines are very versatile and can be adapted to a wide variety of orchard conditions by varying nozzle size and number of nozzles. As more or larger nozzles are utilized, the discharge pressure will decrease and the discharge rate will increase. But as pressure is decreased and discharge rate is increased, the size of the spray particles becomes considerably larger. In concentrate spraying, larger particles are less desirable because they usually do not disperse as high into the tree crown or produce as good coverage as would particles of smaller size.

The number of nozzles built into the various commercial sprayers ranges from one to four for certain types of mist blowers to two dozen or more for certain airblast machines. For most airblast machines, a wide range of discharge rates can be obtained simply by changing nozzle sizes and the number of nozzles in operation and by regulating the pressure. Thus, many airblast rigs can be adjusted for either dilute or concentrate spraying operations.

Tractor Speed

Improper tractor speed is one of the most frequent causes of poor results when seed orchards are sprayed with airblast equipment. Most seed orchardists do not realize that, at any given discharge rate, a slight change in tractor speed results in a large deviation from the gallonage, or amount, of spray material desired per acre.

All too often, the tractor speed selected is too fast, causing poor spray coverage of the trees. The other extreme, which has rarely been observed in seed orchards, is selecting a tractor speed that is too slow. The overspraying which results from a slow tractor speed increases the time and cost of a control operation. At slow speeds, more insecticide is applied per tree than is recommended, thus increasing insecticide costs. Also, the chance of chemical burning of the foliage is greater, especially when concentrates are being applied. An example will help to illustrate the importance of proper tractor speed:

Example: In an orchard with 20 by 20 spacing, a mist blower "nozzled" to discharge 4.20 gallons of spray material per minute discharges 52 gallons/acre when the tractor speed is 2 m.p.h. But at speeds slightly slower or faster than 2 m.p.h., the gallonage per acre varies tremendously:

m.p.h.	*gal./acre*
0.5	208
1.0	104
1.5	70
2.0	52
2.5	41
3.0	34
4.0	26

To find the most desirable tractor speed for a particular orchard, make a test run in the orchard to determine the speed that results in adequate coverage of the trees, and then use the following formula to calculate the rate of speed in miles per hour:

$$\text{Speed (in m.p.h.)} = \frac{\text{Tree spacing (in ft.)} \times \text{number of trees passed per minute}}{88}$$

Example: If the trees are on 30-foot centers and the tractor passes 4.4 trees in one minute, then

$$\frac{30 \times 4.4}{88} = 1.5 \text{ miles per hour}$$

Dilute Application With Airblast Sprayers

Dilute spraying is the application of a small proportion of insecticide in a large volume of water. The percent concentration of dilute spray in airblast machines is usually similar to that used in hydraulic spray rigs.

Most airblast machines commonly used for dilute spraying are equipped with high-volume pumps capable of discharging 100 gallons or more per minute. They have either single- or double-side discharges. In other words, they spray either one side of a single row of trees or one side of each of two rows of trees on each pass (fig. 9). Machines with double-side discharge can usually be converted to single-side discharge by closing off all the nozzles on one side. As a general rule,

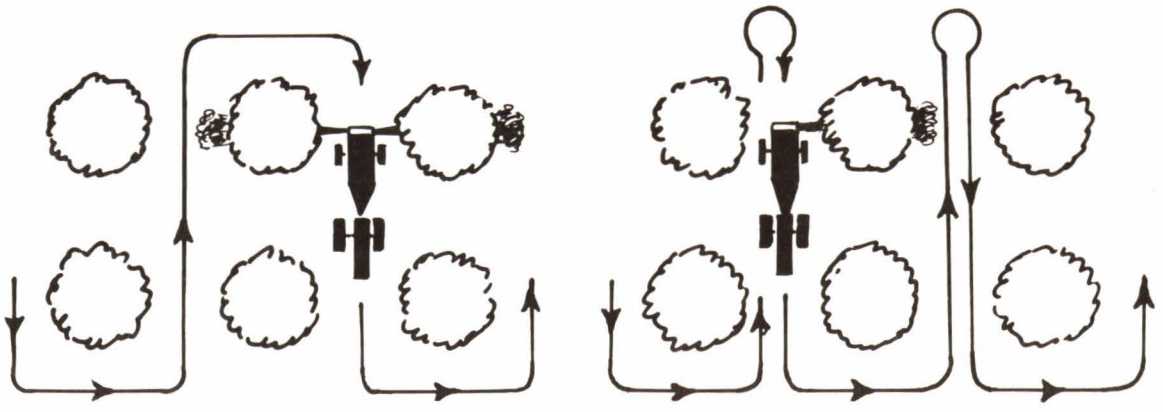

Figure 9.—Left—spraying two rows of trees on each pass with a double-discharge machine. Right—spraying one row of trees on each pass with single-discharge machine.

a machine can spray taller trees when set up for single-side discharge than when set up for double-side discharge.

Orchardists frequently want to know how many gallons of dilute spray to apply to each tree. There is no single correct answer to this question, because the required gallonage per tree depends upon the size and density of the tree crowns in a given orchard. The best way to answer it is to fill the sprayer with water, spray a number of trees (covering them thoroughly), and then calculate the required gallonage per tree. When the required gallonage per tree has been determined, the next step is to calculate the discharge rate that will deliver it.

The following formula is used to calculate the discharge rate for dilute spraying with airblast machines:

$$\text{Discharge rate } \textit{per side}^{*} \text{ (in g.p.m.)} = \frac{G \times T \times 44}{S}$$

*For machines with two-side delivery, each side should discharge this amount.

where G = gallons of dilute spray material per tree, T = tractor speed (in m.p.h.), and S = tree spacing within rows (in feet).

Example: If orchard trees on 30-foot centers within the rows require 4 gallons of dilute spray and the tractor speed is 1.5 m.p.h., then the discharge rate per side can be calculated as follows:

$$\text{Discharge rate } \textit{per side} \text{ (in g.p.m.)} = \frac{4 \times 1.5 \times 44}{30}$$

Discharge rate *per side* = 8.8 g.p.m.

Once the discharge rate has been calculated, it can easily be obtained by proper nozzle selection. Airblast sprayers should be "nozzled" to discharge the heaviest spray volume at "10 and 2 o'clock" (fig. 10), either by the use of more nozzles or nozzles with larger orifices. The deflector above the air outlet should also be adjusted to drive the spray across the tree tops, instead of allowing it to be thrown vertically above the machine.

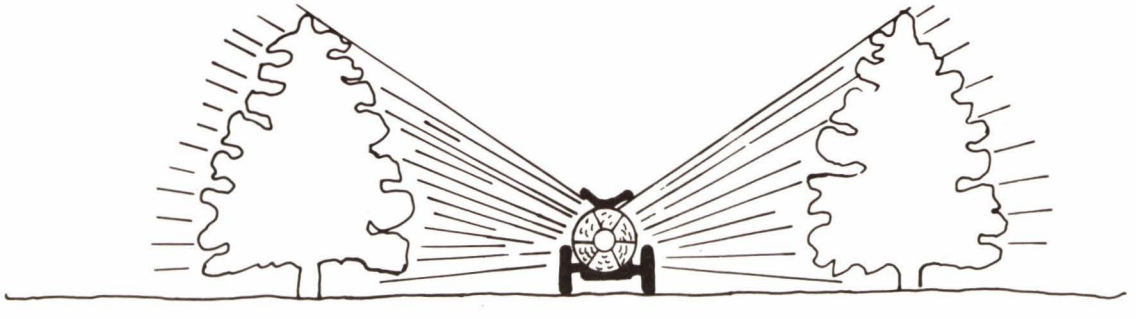

Figure 10.—A double-discharge airblast sprayer correctly "nozzled" to deliver the heaviest volume of dilute spray at "10 and 2 o'clock."

Concentrate Applications With Airblast Sprayers

Concentrate spraying is the application of a large proportion of insecticide in a small volume of water. Mist blowers (figures 7, 11, and 12) are designed specifically for this type of spraying, but many other types of airblast machines can easily be modified for concentrate spray operations. Concentrate spraying requires strict attention to the details of *operation* and *calibration* if it is to be effective in insect control.

The basic theory behind concentrate spraying is that the loss of insecticides as runoff which occurs in dilute spraying will be eliminated if the insecticides are applied in larger proportions and in lower volumes of water than those used in dilute sprays. Thus, if an insecticide is applied at a 6X concentration (6 times the concentration recommended for hydraulic or dilute spraying) and at only 1/8 the dilute gallonage, the result is a 25-percent savings in insecticide costs. Or, looking at it in a more practical light, one tank of 6X concentrate at 1/8 the dilute gallonage is equivalent to eight tanks of dilute spray, and, because only three-fourths of the original amount of insecticide is used, the insecticide cost is reduced by one-quarter. Thus, according to the theory of concentrate spraying, a tree normally requiring 8 gallons of dilute spray would need only 1 gallon of 6X concentrate spray.

Because of the extremely high density of pine foliage and the difficulties we have experienced in getting good coverage in pine seed orchards, it does not seem advisable to reduce the gallonage per tree by more than the factor of the increase in concentration. Although there are no savings of insecticide if this rule is followed, concentrate spraying does reduce the volume of water and the time required to spray an orchard (table 2).

Figure 11.—A mist blower used in a pine seed orchard to apply a low volume of highly concentrated spray.

The following formula is used to calculate the discharge rate for concentrate spraying in seed orchards:

$$\text{Discharge rate } \textit{per side}^{*} \text{ (in g.p.m.)} = \frac{G \times T \times 44}{X \times S}$$

*For machines with two-side delivery, each side should discharge this amount.

where G = gallons of dilute spray per tree, T = tractor speed in m.p.h., X = the concentration (X = 1 for dilute sprays), and S = tree spacing within the rows in feet.

Example: If orchard trees on 30-foot centers within the rows require 4 gallons of dilute spray and the tractor speed is set at 1.0 m.p.h., then the discharge rate for a machine applying a 6X concentrate can be calculated as follows:

$$\text{Discharge rate (in g.p.m.)} = \frac{4 \text{ gal.} \times 1.0 \text{ m.p.h.} \times 44}{6X \times 30}$$

Discharge rate *per side* = 0.98 g.p.m.

Once the discharge rate has been calculated, it can easily be obtained by proper nozzle selection. The discharge rate per nozzle (in g.p.m.) for specific nozzles and pressures can be found in the catalog of the equipment manufacturer.

Table 2.—Gallonage of concentrate spray recommended per tree

Gallonage of dilute spray (X concentration) required per tree	Gallonage recommended per tree when concentration is—						
	2X	3X	4X	5X	6X	7X	8X
5	2.50	1.64	1.26	1.00	0.82	0.72	0.62
8	4.00	2.66	2.00	1.60	1.34	1.14	1.00
10	5.00	3.34	2.50	2.00	1.66	1.42	1.26
12	6.00	4.00	3.00	2.40	2.00	1.72	1.50
14	7.00	4.66	3.50	2.80	2.34	2.00	1.76
16	8.00	5.34	4.00	3.20	2.66	2.28	2.00
18	9.00	6.00	4.50	3.60	3.00	2.58	2.26
20	10.00	6.66	5.00	4.00	3.34	2.86	2.50

Figure 12.—A truck-mounted mist blower.

For the best possible coverage of each tree, the nozzles and air discharge should be directed so that approximately 50 percent of the total gallonage goes into the upper one-third of the crown and 70 percent goes into the upper half of the crown (fig. 13). Finally, if maximum coverage is to be achieved, *tractor speeds must be kept slow.* One m.p.h. is often recommended as a good speed for concentrate applications.

During the day, the most favorable conditions for concentrate applications exist 1 to 2 hours after sunrise and 1 to 2 hours prior to sunset. In many respects, conditions for spraying are even more favorable at night, for the following reasons:

1. Calm conditions exist, air currents move downward, and the small spray droplets settle readily; these factors result in better tree coverage. The hazard of driftback to the operator is also reduced.

2. Concentrate sprays can be observed more readily at night than during the day. Thus, malfunctioning spray nozzles and improperly directed sprays can be detected.

3. The higher humidity which occurs at night reduces evaporation, and the spray particles settle without the further concentration which results from rapid drying.

4. Cool night temperatures make it more comfortable for the operator, who must wear a respirator and protective clothing.

Calibrating Airblast Sprayers With a Trial Run

In order to check the operation of an airblast sprayer and determine if the gallonage delivered per tree is accurate, the operator should conduct a trial run. These are the steps that should be followed:

1. Fit the machine with the nozzles that will provide the calculated discharge rate.

2. Set the tractor throttle for the desired speed.

3. Spray a predetermined number of trees with water.

4. Measure the volume of water used.

5. Calculate the gallonage per tree.

6. If the calculated gallonage per tree does not agree with the gallonage that is required for complete coverage, make the necessary changes in nozzles and pressures and repeat until the desired gallonage is obtained.

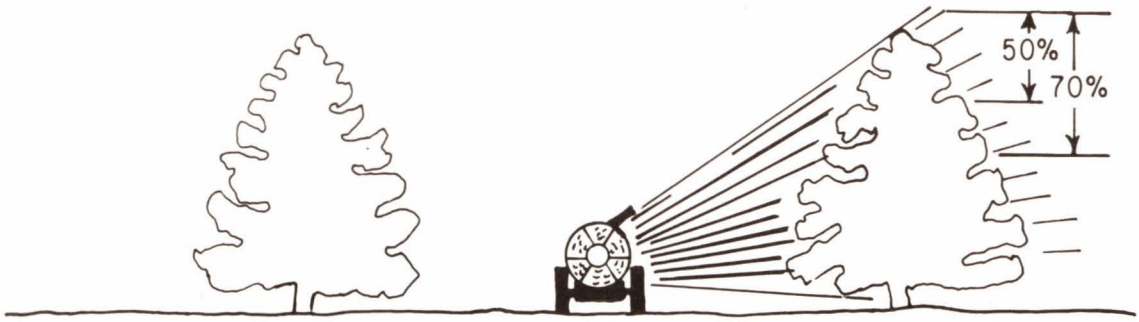

Figure 13.—A single-discharge airblast sprayer "nozzled" to deliver approximately 50 percent of the total gallonage in the upper one-third of the crown and 70 percent in the upper half of the crown.

CONCLUSION

This guide is intended to familiarize seed orchard managers with the precautions necessary for the safe handling and application of insecticides. It also provides an introduction to the characteristics of the spray machines that can be used in insect control programs. It cannot be overemphasized that a successful spray program can only be obtained by observing the proper safety precautions and carefully calibrating the machines.

The appendices which follow contain formulas and tables for mixing insecticides, a glossary of important terms, and a list of selected references that can be consulted for more detailed information.

APPENDIX I

Insecticide Dilution Formulas

The amount of insecticide needed to mix a spray containing a given percentage of active ingredient is calculated as follows:

$$\text{Amount of concentrate required} = \frac{\text{Gal. of spray material needed} \times \text{percentage of active ingredient required} \times 8.345^{*}}{\text{Lb. of active ingredient per gal. of liquid}^{**} \text{ or per lb. of wettable powder} \times 100}$$

Example 1: How many gallons of BHC (1-lb. active ingredient) are needed to make 200 gallons of spray material containing 2.5 percent active ingredient?

$$\frac{200 \text{ gal.} \times 2.5\% \times 8.345^{*}}{1 \text{ lb./gal.} \times 100} = 41.7 \text{ gal.}$$

Example 2: How many pounds of malathion (25 percent wettable powder) are needed to make 75 gallons of spray material containing 1 percent active ingredient?

$$\frac{75 \text{ gal.} \times 1\% \times 8.345^{*}}{0.25 \text{ lb. of active ingredient/lb.} \times 100} = 25 \text{ lb.}$$

*8.345 = the weight (in lb.) of 1 gallon of water.

**Pounds of active ingredient per gallon is usually given on the label. If the label fails to show this information, multiply the weight in pounds of a gallon of concentrate by the percentage of active ingredient it contains.

APPENDIX II

Dilution Table

These are the **approximate** amounts of concentrate to use for mixing sprays.[1] To obtain a spray mixture with the required percentage of a chemical, use the amount of formulation indicated in the table in 100 gallons of water. The figures in parentheses indicate the amount to use in 1 gallon of water.

Formulation	Amount of formulation to use when desired percentage of chemicals in mixture is—						
	.03125%	.0625%	0.125%	0.25%	0.5%	1.0%	2.0%
10%-12% E. C. containing 1 lb. of chemical per gal.	2 pt. (2 tsp.)	4 pt. (4 tsp.)	1 gal. (8 tsp.)	2 gal. (16 tsp.)	4 gal. (10 tbsp.)	8 gal. (2/3 pt.)	16 gal. (1-1/3 pt.)
15%-20% E. C. containing 1-1/2 lb. of chemical per gal.	1-1/2 pt. (1-1/2 tsp.)	3 pt. (3 tsp.)	6 pt. (6 tsp.)	1-1/2 gal. (12 tsp.)	3 gal. (7-1/2 tbsp.)	6 gal. (1/2 pt.)	12 gal. (1 pt.)
25% E. C. containing 2 lb. of chemical per gal.	1 pt. (1 tsp.)	2 pt. (2 tsp.)	4 pt. (4 tsp.)	1 gal. (8 tsp.)	2 gal. (5 tbsp.)	4 gal. (10 tbsp.)	8 gal. (2/3 pt.)
33%-35% E. C. containing 3 lb. of chemical per gal.	3/4 pt. (3/4 tsp.)	1-1/2 pt. (1-1/2 tsp.)	3 pt. (3 tsp.)	6 pt. (6 tsp.)	1-1/2 gal. (4 tbsp.)	3 gal. (8 tbsp.)	6 gal. (1/2 pt.)
40%-50% E. C. containing 4 lb. of chemical per gal.	1/2 pt. (1/2 tsp.)	1 pt. (1 tsp.)	2 pt. (2 tsp.)	4 pt. (4 tsp.)	1 gal. (8 tsp.)	2 gal. (5 tbsp.)	4 gal. (10 tbsp.)
57% E. C. containing 5 lb. of chemical per gal.	7/16 pt. (7/16 tsp.)	7/8 pt. (7/8 tsp.)	1-3/4 pt. (1-3/4 tsp.)	3-1/2 pt. (3-1/2 tsp.)	7 pt. (7 tsp.)	1-3/4 gal. (4-1/2 tbsp.)	3-1/2 gal. (9 tbsp.)
60%-65% E. C. containing 6 lb. of chemical per gal.	3/8 pt. (3/8 tsp.)	3/4 pt. (3/4 tsp.)	1-1/2 pt. (1/2 tbsp.)	3 pt. (1 tbsp.)	6 pt. (2 tbsp.)	1-1/2 gal. (4 tbsp.)	3 gal. (8 tbsp.)
70%-75% E. C. containing 8 lb. of chemical per gal.	1/4 pt. (1/4 tsp.)	1/2 pt. (1/2 tsp.)	1 pt. (1 tsp.)	2 pt. (2 tsp.)	4 pt. (4 tsp.)	1 gal. (8 tsp.)	2 gal. (5 tbsp.)
15% wettable powder	1-2/3 lb. (2-1/2 tsp.)	3-1/3 lb. (5 tsp.)	6-2/3 lb. (10 tsp.)	13-1/3 lb. (7 tbsp.)	26-2/3 lb. (1 cup)	53-1/3 lb. (2 cups)	106-2/3 lb. (4 cups)
25% wettable powder	1 lb. (1-1/2 tsp.)	2 lb. (3 tsp.)	4 lb. (6 tsp.)	8 lb. (12 tsp.)	16 lb. (8 tbsp.)	32 lb. (1 cup)	64 lb. (2 cups)
40% wettable powder	5/8 lb. (1 tsp.)	1-1/4 lb. (2 tsp.)	2-1/2 lb. (4 tsp.)	5 lb. (8 tsp.)	10 lb. (5 tbsp.)	20 lb. (10 tbsp.)	40 lb. (1-1/4 cups)
50% wettable powder	1/2 lb. (3/4 tsp.)	1 lb. (1-1/2 tsp.)	2 lb. (3 tsp.)	4 lb. (6 tsp.)	8 lb. (4 tbsp.)	16 lb. (8 tbsp.)	32 lb. (1 cup)
75% wettable powder	1/3 lb. (1/2 tsp.)	2/3 lb. (1 tsp.)	1-1/3 lb. (2 tsp.)	2-2/3 lb. (4 tsp.)	5 1/3 lb. (8 tsp.)	10-2/3 lb. (5 tbsp.)	21-1/3 lb. (10 tbsp.)

[1] To obtain more precise proportions, use the formulas given on the preceding page.

APPENDIX III

Glossary of Important Terms

Acute dermal toxicity—The lethal dosage of an insecticide when it is absorbed through the skin.

Acute oral toxicity—The lethal dosage of an insecticide when it is ingested or taken in through the mouth.

Calibration — The determination of the discharge rate and gallonage of a machine under field conditions. A trial run is often used to make this determination.

Concentrate spraying—The application of a large proportion of insecticide in a low volume of water, often done with a mist blower.

Discharge rate—The volume of spray delivered from a spray machine, expressed in gallons per minute.

Dilute spraying—The application of a small proportion of insecticide in a large volume of water, as is done with a hydraulic sprayer.

E. C.—Emulsifiable concentrate.

Gallonage—The volume of spray applied per unit or unit area, such as gallons per tree, gallons per acre, etc.

g.p.m. — Gallons per minute — the standard form for expressing capacity or discharge rate of spray pump.

Nozzle size—Refers to the nozzle opening or orifice; nozzles are sized by the manufacturers in numbered series equivalent to fractions (64ths) of an inch.

p.s.i. — Pounds per square inch — unit of measurement of pressure.

Residual sprays—Spray applications of insecticides which form a fine deposit on exposed surfaces. Insects resting or walking on the surfaces contact the insecticide or ingest it when feeding.

Systemics—Insecticides that have the unique advantage of being absorbed and translocated within a tree, thus rendering certain plant tissues toxic to insects.

APPENDIX IV

Selected References

Bailey, S. F., and Smith, L. M. 1951. Handbook of agricultural pest control. New York: Industry Publications, Inc.

Ebel, B. H. 1965. Control of thrips on slash pine female strobili. J. Forest. 63: 287-288.

Merkel, E. P. 1964. Hydraulic spray applications of insecticides for the control of slash pine cone and seed insects. Southeast. Forest Exp. Sta., U. S. Forest Serv. Res. Pap. SE-9, 7 pp.

Merkel, E. P., and Yandle, D. O. 1965. Mist blower applications of insecticides for cone insect control on slash pine. Southeast. Forest Exp. Sta., U. S. Forest Serv. Res. Note SE-52, 4 pp.

Potts, S. F. 1958. Concentrated spray equipment. Caldwell, N. J.: Dorland Books.

U. S. Department of Agriculture. 1967. Safe use of agricultural and household pesticides. Agr. Handbook 321. U. S. Government Printing Office, Washington, D. C. (An excellent reference on safety in handling and applying pesticides.)

U. S. Forest Service. 1966. Handbook of pest identification and control in seed orchards and seed production areas. Sponsored Pub. 27, Comm. South. Forest Tree Impr. and U. S. Forest Serv., Southeast. Area, Div. State and Priv. Forest., Atlanta, Ga.

Wolford, Dale E. 1964. Technical manual—orchard and row crop air sprayers. Adver. Dep., F. E. Meyers & Brothers, Co., Ashland, Ohio.
(Gives the basic information on selecting and operating airblast machines in orchards.)

Yates, Harry O. III, and Lewis, William G. 1969. An accurate and safe hand-operated, vehicle-mounted applicator for granular insecticides in seed orchards. J. Econ. Entomol. 62: 246-248.

Yeomans, A. H., Fulton, R. A., Smith, F. F., and Busbey, Ruth L. 1966. Respiratory devices for protection against certain pesticides. U.S.D.A. Agr. Res. Serv. Rep. ARS 33-76-2.

Pesticides used improperly can be injurious to man, animals, and plants. Follow the directions and heed all precautions on the labels.

Store pesticides in original containers under lock and key — out of the reach of children and animals — and away from food and feed.

Apply pesticides so that they do not endanger humans, livestock, crops, beneficial insects, fish, and wildlife. Do not apply pesticides when there is danger of drift, when honey bees or other pollinating insects are visiting plants, or in ways that may contaminate water or leave illegal residues.

Avoid prolonged inhalation of pesticide sprays or dusts; wear protective clothing and equipment if specified on the container.

If your hands become contaminated with a pesticide, do not eat or drink until you have washed. In case a pesticide is swallowed or gets in the eyes, follow the first aid treatment given on the label, and get prompt medical attention. If a pesticide is spilled on your skin or clothing, remove clothing immediately and wash skin thoroughly.

Do not clean spray equipment or dump excess spray material near ponds, streams, or wells. Because it is difficult to remove all traces of herbicides from equipment, do not use the same equipment for insecticides or fungicides that you use for herbicides.

Dispose of empty pesticide containers promptly. Have them buried at a sanitary land-fill dump, or crush and bury them in a level, isolated place.

NOTE: Some States have restrictions on the use of certain pesticides. Check your State and local regulations. Also, because registrations of pesticides are under constant review by the U. S. Department of Agriculture, consult your county agricultural agent or State Extension specialist to be sure the intended use is still registered.